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SOME PINEAPPLE PROBLEMS.

ART. 22. - FRUIT MATURITY.

By Henry C. Henricksen.

The pineapple is most desirable for consumption when plant-ripened; therefore, the standard of maturity is naturally the plant-ripened fruit, that is the fruit which has been left on the plant until it is fully colored and picked before it has begun to deteriorate. At that stage of maturity it is best for immediate consumption, but it is not suitable for long distance shipment because the tissue is too soft to withstand the weight of the surrounding fruit when packed several in a container; neither can it be kept very long, except at a low temperature, because of the enzymatic changes taking place which result in deterioration. The planters' problem is, therefore, to pick fruit at such a stage of maturity that it will reach the market in good condition and yet be as near as possible to the plant-ripened fruit in quality. This problem is not simple as is well illustrated by the variation in maturity of most of the fruit now shipped. The outward indications of maturity are very difficult to recognize and often the pickers fail to do so because they do not know that variations are caused by soil, fertilizer, moisture and temperature.

OUTWARD VISIBLE MATURITY CHANGES. - These cannot be described precisely nor can anyone learn to recognize them from a description without having fruit at various stages of maturity to refer to. The condition of the bracts or leaflets at the base of the eyes is a sure indication up to a certain point; as long as these are not entirely wilted the fruit should not be picked. The next sure indication is the color of the basal eyes; if a slight yellow color is visible the fruit is of shipping maturity. But between these two extremes the indications are not readily discernible. One indication is a flattening of the eyes to the extent that the central point is almost even with the marginal shoulders, but that does not take place consistently in all fruit nor under all conditions. The color is a contributory indication but it is useful to those only who are well familiar with local conditions under which the fruit has been grown. On each plantation a number of minor indications are used none of which are infallible and many of which are misleading. This can be remedied in the following manner: Leave a few fruits to ripen on the plants in order to have some for use as standards when needed. From time to time pick two or more fruit at the following stages of maturity. (1) Showing color at butt. (2) Showing no color but, according to various indications, appearing to be mature enough for color to develop within a week. (3) Less mature than former or doubtful. Also label some other fruits in the field which appear to be at the same stages of maturity as the lots just picked, and a week or more hence note the appearance of them and compare with the picked fruit.

Wrap the picked fruit and keep it in a cool place for a week or more and then make the following tests: Cut a fruit of each lot and note the texture and flavor of the flesh. Peel the fruit, cut it in strips and pulp it by running it through a food chopper. Pour the pulped mass onto a piece of muslin and squeeze the juice out. Note the color, taste and viscosity of the juice and determine the total solids with a hydrometer. Make a tabulation of the points noted in the following manner:

COMPARISON OF FRUIT PICKED AT DIFFERENT STAGES OF MATURITY.
ALL WERE TESTED SEVEN DAYS AFTER PICKING EXCEPT THE
PLANT-RIPENED FRUIT WHICH WAS PICKED IMMEDIATELY BEFORE TESTING.

STAGES OF MATURITY.

Points of comparison	Plant-ripened.	Showing color at butt.	One week from coloring at butt.	Doubtful.
OUTSIDE				
Color	Reddish yellow	Like former.	Inferior to former.	Grayish green.
Gloss	Glossy	Like former.		
FLESH				
Texture	Tender.	Like former.	Much firmer than former.	Firm and brittle.
Flavor	Well developed.	Like former.	Less than former.	Not developed.
JUICE				
Color	Orange yellow.	Like former.	Pale yellow.	Milky white yellowish tinge.
Taste	Very mellow.	Sharper than former.	Very sharp.	Insipid.
Viscousness	Very little.	Like former.	Much more than former.	Very viscous.
Total solids	14.5	13.5	12.0	9.5

The notes in the foregoing table are representative of such tabulations provided no mistakes have been made in regard to the stages of maturity. The plant-ripened fruit is of a uniform yellow color usually deeply tinged with red and if the coloring has developed without sunburning the surface of the eyes will appear glossy The texture of the flesh is so that the juice separates readily from the pulp and the typical pineapple flavor is well developed. The color of the juice is a deep yellow or orange, the taste is mellow, the consistency is like that of water, but slightly mucilagenous and the percent of total solids is usually 14 to 15. In exceptional cases the percentage may be as high as 16 to 16.5 but if the fruit is yellow because of sunburn it may be much less than 14. Normal representative fruit should always be selected and the entire fruit should be pulped. The latter is necessary because the first and second slices at the base usually contain 2 to 4% more total solids than the corresponding slices at the apex.

The fruit that is slightly colored at the butt when picked and noted in the next column of the table colors and retains its gloss after picking. The flesh softens and the flavor develops as in the plant-ripened fruit. The juice is also similar in color and viscosity but the taste may not be as mellow as that of the former and the total solids content is liable to be lower. The sugar content of a pineapple continues to increase as long as the fruit is left on the plant, up to the time when decay begins to take place, but picking arrests the sugar development regardless of the stage of maturity of the fruit. This has been reported by other

investigators and it was definitely proved in this investigation in the following manner: Plugs were removed from fruit, at several days interval, under aseptic conditions and the cavities were filled with melted paraffin. In that manner no decay took place and the maturity changes proceeded normally. The juice in the plugs was tested by means of an Abbé refractometer and no changes in the total solids content were observed even in fruit kept two weeks or more.

The quality of the third fruit, mentioned in the table, will depend upon the judgement of the picker. It will be colored to some extent but the color will seldom be equal to that of the plant-ripened fruit. Neither will the quality of the flesh nor the juice be as desirable, but with a total solids content of 12% compared with 14.5% of the plant-ripened fruit this cannot justly be called immature.

The fourth fruit listed in the table, under the heading doubtful, is manifestly immature and it is especially for the elimination of this class of fruit that these tests are valuable. The experience gained by conducting such test will teach the pickers to recognize maturity indications and convince the growers of the value of picking nothing but mature fruit.

CATALASE IN THE RIND. - A determination of catalase by the method described in the 16th Article of this series may prove to be a very valuable measure of maturity. In preliminary trials made with fruit in different stages of maturity the results show that the rind of an immature fruit liberates much more oxygen from hydrogen peroxide than that of a mature fruit. The tests should be made immediately after picking. The material to be tested should be pared in thin slices from the shoulders of the eyes. One-half gram of this sliced material should be minced fine and macerated in a mortar with chalk and water, after which the volume should be made to 10 cc. with water and the mass left for 18 to 24 hours before testing.

CHEMICAL TESTS. - Although few growers are prepared to perform chemical work all are interested in it provided it concerns their business. In the course of these investigations it has been necessary for the investigator to do considerable such work in order to gain a better understanding of the problems involved. It is hoped that a brief discussion of some of the results obtained may be helpful to others.

WATER CONTENT. - The flesh of an immature fruit is firm compared to that of a plant-ripened fruit and it appears to be much drier, but actually the difference in moisture content is not very great as shown by drying samples from fruit in various stages of maturity. The immature fruit contains about 84% moisture against 88% in the plant-ripened, but these figures are very general; some fruit may contain as low as 80% moisture and others as high as 92%.

The apparent dryness of the flesh is due to the firmness of the tissue. On keeping the fruit for some time after picking the tissue softens considerably and the juice can be separated from the pulp more readily. To illustrate that a dozen fruit were picked when very immature, six of them were peeled and pulped immediately and the juice squeezed out through muslin by hand, with the result that an average of 54% juice was obtained, calculated on the peeled fruit. The other six fruits were kept at a temperature of 80°F for 16 days, at the end of which time they were

as colored and tender as such fruit becomes. The juice was then squeezed out as in the former case and an average of 71.5% was obtained. Another lot of fruit, slightly more mature, yielded 60.2% juice immediately after picking and 73.3% after being kept 14 days.

THE JUICE. - This contains not alone the water-soluble acids and sugar but also some colloidal matter. The acids which chiefly cause the acidity of the juice are according to E. K. Nelson, of the Bureau of Chemistry, United States Department of Agriculture, citric 87% and malic 13%. The acidity as measured by titration with alkali is found to be usually below 0.4% in the undeveloped fruit and 0.4 to 0.9% in that which is fully developed and nearly mature. The variations do not, however, parallel maturity indications and the acid content is, therefore, not a useful measure of maturity. The acid content does not change after the fruit is picked until decay sets in when it does diminish rapidly.

The sugars present are partly glucose and partly sucrose or more correctly reducing and non-reducing. The relative proportions of the two change with maturity about as follows: In the half-developed fruit the proportions are about equal; in the fully developed the ratio is about 1 reducing to 2-1/2 non-reducing and in the plant-ripened 1 to 3 or 1 to 4.

The high content of reducing sugars in the undeveloped fruit is not due to the presence of invertase; this is not present in the fruit at that stage. A small amount develops with maturity and it appears to increase even after the fruit has been picked. It is difficult, however, to determine whether or not that is correct for the amount present varies in different fruits and the variation is especially marked when comparing fruit from different plantations.

As an indication of the reduction that may take place the following example will serve. Fifty cc. juice from a plant-ripened fruit with 4 grams sucrose was kept for 48 hours at a temperature of 28°C. with the result that 15 mg. reducing sugar was produced. This would seem to indicate that considerable reduction takes place when mature fruit is kept for some time. There may, however, be a reverse action also. That is difficult to determine under the circumstances, but the fact remains that the fruit containing the most sucrose also contains the most invertase.

Mucilagenous matter is present in larger amount in the juice of the green than in the ripe fruit but the difference in viscosity is not due so much to the quantity as to the quality of it. In the green fruit the mucilagenous and pectinous matter in the juice is the building material, so to speak, of which the tissues of the fruit are formed. In the ripe fruit, on the other hand, the matter causing viscosity of the juice is largely degradation products of the tissues. This is of considerable importance for the latter are palatable whereas the former are not. The juice from an immature fruit with the addition of citric acid, sugar and pineapple flavor does not resemble that of a mature fruit.

The red and yellow pigments of the pineapple are water soluble and, therefore, the juice is considerably colored even though the color may not be visible in the flesh; also the pigments appear in the juice a long time before they are discernible in the rind. The green and bronze colors of the rind vary in intensity according to soil, fertilizer and light. Some red clay soils produce beautifully dark bronze, nearly black fruit; whereas those grown on sandy soil are lighter in color and if the plants are fertilized with nitrates the color of the fruit is pea-green. Strong direct sunlight destroys the pigments and, therefore, fruits that are partly shaded by the surrounding leaves are usually of better appearance than those that are freely exposed. The maturity pigments are developed in the rind as in the flesh after the fruit is picked, but to a much less extent than in the growing fruit.

THE PULP. - This consists of cellulose fibre embedded in a pectinous hemi-cellulose tissue. This tissue is evidently not hydrolyzed to completion, to sugar formation, by the enzymes of the fruit, at least not after picking. Starch is present in negligible quantities only and likewise diastase which hydrolyzes starch. But the changes in the pectinous tissue might be expected to go to sugar formation. Perhaps it does but the action is so slow that it is not noticeable. Pectase, for instance, which is active towards pectin is not present in the juice in appreciable quantities even in the ripe fruit; in the green fruit it would not be expected, for tissue building is a condensation rather than a degradation process. The building materials are chiefly carbohydrates which move from the plant-stalk in true or colloidal solution. Some of them are changed into acids, sugars and the various products characteristic of the pineapple; others are deposited as tissue which does not ordinarily enter into solution again until the fruit matures. This tissue contains 25 to 35% carbohydrates that are hydrolyzable by 1% hydrochloric acid; that is to say, material which is known to be subject to hydrolysis by enzymes in living plants. It is true that most of the product resulting from hydrolysis consists of pentose sugars showing that the hydrolyzable tissue is chiefly pentosans and that may be partly the reason for the slow changes after the fruit is picked. In the ripening process some very vigorous actions are involved while the fruit is on the plant. For instance, the sugar content may increase as much as 5% in two weeks, most of which sugar is sucrose, and the pectinous tissue may become greatly changed. After picking, however, the sugar formation is arrested and the tissue changes are much delayed.

NITROGEN IN THE FRUIT. - Nitrates are present in perceptible quantity especially in the green fruit. This may be accounted for by the presence of the crown, since it is necessary throughout the growing period for the devlopment of that appendix.

The crown is an independent plant and it needs inorganic material for development as well as a plant growing in the soil. Nitrates, for instance, are present in the leaves and the quantity of it denotes the vigor of growth as it does in the mother plant. This may be proved by a nitrate determination as described in the 15th Article of this series.

Nitrogen in the form of protein is present in quantities ranging from 3 to 6% calculated on the dry bases. The quantity being larger in the green than in the ripe fruit.

CALCIUM OXALATE CRYSTALS. - The sharp sensation on the tongue which appears after eating pineapples is due largely to needle-shaped crystals of microscopic size that are imbedded in the pulp. The crystals are present in mature and immature fruit alike but they are more noticeable in the latter because the tissue is more difficult to masticate and the more thorough mastication produces a more intense sensation. Those to whom this sensation is objectionable may pulp the fruit, extract the juice and discard the pulp. In doing so the crystals are not entirely eliminated, a portion passes through the strainer and they are insoluble in the juice, but in drinking the juice the objectionable sensation is eliminated.

G U M M I N G . - Frequently a gummy exudation is found on pineapples that are nearly mature. The gum exudes in spots between the eyes that are located towards the base; it is seldom found above the middle of the fruit. The exudations occur on a few fruit at any time during the year and often on a large percent of the crop during a prolonged drought or during rainy weather following a drought. The gum exudes as a viscous, colorless or white mass which on exposure to the air hardens and assumes the color of amber. It resembles wound gum in outward appearance but it usually exudes where no wound is detectable.

Gumming was referred to in the 15th Article of this series where it was explained on the assumption that mucilagenous products are found in abnormal quantities when the plant is in need of water. The mucilagenous products absorb moisture from the tissue surrounding that in which it was formed and by swelling it is forced through the epidermis in spots where the resistance is least. The gum is different from typical wound gum in behavior and composition. It is partly soluble in water and the water-soluble portion contains both reducing and non-reducing sugars. The water-insoluble portion is entirely soluble in acid and the acid solution contains sugar most of which is arabinose.

The gummy exudation does not appear to impair the quality of the fruit. Growers who aim to ship a first class product always pick the gum off before the fruit is packed and in that manner eliminate all traces of it.